Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)
Review of Part 15 and other	) ET Docket 01-278
Parts of the Commission's Rules.	) RM-9375
	) RM-10051

March 23, 2002

NOTICE OF EX-PARTE PRESENTATION SUBMITTED BY MR. GERALD W. MURRAY (WA2IWW) IN RESPONSE TO NOTICE OF PROPOSED RULEMAKING (RM-10051)

I. INTRODUCTION

During the Comment and Reply Comment periods for this proceeding, Savi claimed that the ARRL had provided figures which were in error by 30 dB. On the last day of the Reply Comment period (March 12, 2002), Savi repeated this claim and revised their estimate of the error to 33.6 dB.

Using information obtained from the multiple ARRL and Savi filings, I believe that I have determined the reasons for the discrepancies which are the basis for the dispute. Since the mathematics in this proceeding is of critical importance, the accurate settlement of this issue is in the best interest of the parties, the Commission, and the public.

Some of the most crucial information required for the resolution of this issue was provided in the Savi filing of March 12, 2002 (the last day of the Reply Comment period). I submit that it is in the public interest, convenience and necessity to resolve this dispute. Accordingly, I request that the FCC accept this submission as ex-parte or late-filed.

II. BACKGROUND

My name is Gerald W. Murray. I have held Amateur Radio license WA2IWW since 1976, and have held the Amateur Extra class license since 1992.

I also hold the following FCC commercial radio operator licenses:

General Radiotelephone Operator License (GROL) with Ship Radar Endorsement

Second Class Radiotelegraph Operator's Certificate with Ship Radar Endorsement

GMDSS Radio Operator/Maintainer License with Ship Radar Endorsement

I am currently employed as a Data Communications Specialist II by the New York State Workers' Compensation Board (NYSWCB). I had previously been employed as a broadcast operator by AM and FM broadcast stations in Upstate New York's Capital District Area.

III. DISCUSSION

SAVI EQUATIONS

On page 18 of the Savi Reply Comments of March 12, 2002, Savi repeats their claim that the ARRL is in error, and revises their estimate of the error to 33.6 dB (a factor of approximately 2,291). Savi lists a 3-step procedure for determining the received signal levels (RSLs) at various distances from the signal source:

"Savi was at first unable to determine the source of the ARRL 30 dB error in its January 14, 2002 study presentation due to the limited detail presented. Savi at first thought that the error might be due to a simple mislabel of the axis of its plots, i.e. dBm instead of the dBW shown. ***The ARRL Ex Parte presentation of February 26, 2002 has shown the source of this error, 33.6 dB.*** *Equation 1.0 used by the ARRL for its calculations attempts to convert field strength to power and account for free-space path loss is incorrect. The field strength as proposed by the rulemaking is specified in terms of microvolts per meter at three meters from the source. To determine the received signal levels at various distances from the source in dBm or dBW, one must use the following process.*

1. Convert the RF field strength to power using (1)

P(dBm) = -77 + 20 Log E(microvolts/meter) – 20 Log F(MHz)
or
P(dBW) = -107 + 20 Log E(microvolts/meter) – 20 Log F(MHz)"

1. Savi correctly uses this equation to compute a received signal level (RSL) of -28.17 dBm (-58.17 dBW) at the 3 meter reference point. This value is fairly close to the –28.92 dBm (-58.92 dBW) figure which is specified by the ARRL.

If actual values are substituted into this equation, the results are:

P(dBm) = -77 + 20 Log E(microvolts/meter) – 20 Log F(MHz)
P(dBm) = -77 + Log (110,000) – 20 Log (433.92)
P(dBm) = -77 + 100.82 – 52.85
P(dBm) = -29.02 dBm

or

P(dBW) = -107 + 20 Log E(microvolts/meter) – 20 Log F(MHz)
P(dBW) = -107 + Log (110,000) – 20 Log (433.92)

P(dBW) = -107 + 100.82 – 52.85
P(dBW) = -59.02 dBW

These results are reasonably close to the figures claimed by the ARRL and Savi:

ARRL: -28.92 dBm (-58.92 dBW)

Savi: -28.17 dBm (-58.17 dBW)

If one wishes to use this formula to compute the received signal level (RSL) for distances other than the reference distance of 3 meters, a distance term may be employed. The term is +20 log (D1/D2), where D1 is the distance of interest, and D2 is 3 meters (the reference distance). This is the method used by the ARRL to prepare their tabulated figures and graphs.

"2. Calculate the free-space loss using (2)

L(dB) = 32.45 + 20 Log D(km) + 20 Log F(MHz)"

2. This equation is used to calculate the path loss to the point of interest. However, this formula should be used between the signal source and the point of interest, not between the 3-meter reference point and a second point.

If actual values are substituted into this equation, the loss for 1 km is:

L(dB) = 32.45 + 20 Log D(km) + 20 Log F(MHz)
L(dB) = 32.45 + 20 Log D(1) + 20 Log F(433.92)
L(dB) = 32.45 + (0) + 52.85
L(dB) = 85.30

If actual values are substituted into this equation, the loss for 0.1 km is:

$$L(dB) = 32.45 + 20 \text{ Log } D(km) + 20 \text{ Log } F(MHz)$$
$$L(dB) = 32.45 + 20 \text{ Log } D(0.1) + 20 \text{ Log } F(433.92)$$
$$L(dB) = 32.45 + (-20) + 52.85$$
$$L(dB) = 65.30$$

"3. Determine the receive signal level (RSL) by algebraically adding the signal level of the source and the free space loss (2)

RSL(dBm) + P(dBm) + L(dB)
or
RSL(dBW) + P(dBW) + L(dB")

3. Savi actually states the correct intent for Equation 3, but mis-applies the equation by assuming the value of the power term to be the –28.17 dBm (-58.17 dBW) received signal level (RSL) Savi calculated at the reference distance of 3 meters.   To quote Savi, one should "Determine the receive signal level (RSL) by algebraically adding the signal level of the source and the free space loss (2)". Since Savi Equation 1 calculates the received signal level (RSL) at the 3-meter reference point (-28.17 dBm or -58.17 dBW), attempts to use this figure as the EIRP of the signal source are inappropriate.

IV. INCORRECT RESULTS OBTAINED BY SAVI'S INAPPROPRIATE USE OF THE RECEIVED SIGNAL LEVEL (RSL) AT THE 3-METER REFERENCE POINT (SAVI METHOD)

By inappropriately summing the received signal level (RSL) at the 3 meter reference point (derived using Savi Equation 1) with the path loss (using Savi Equation 2), the following (incorrect) results are obtained:

1 kilometer

RSL(dBm) = P(dBm) + L(dB)
RSL(dBm) = (-28.17) + (-85.30)
RSL(dBm) = -113.47 dBm

or

RSL(dBW) = P(dBW) + L(dB)
RSL(dBW) = (-58.17)+ (-85.30)
RSL(dBW) = -143.47 dBW

These results are reasonably close to the figures reported by Savi for 1 kilometer (-112.57 dBm or -142.57 dBW)

0.1 kilometer

RSL(dBm) = P(dBm) + L(dB)
RSL(dBm) = (-28.17) + (-65.30)
RSL(dBm) = -93.47 dBm

or

RSL(dBW) = P(dBW) + L(dB)
RSL(dBW) = (-58.17)+ (-65.30)
RSL(dBW) = -123.47 dBW

These results are reasonably close to the figures reported by Savi for 0.1 kilometer (-92.57 dBm or -122.57 dBW)

Although the results are in close agreement with those provided by Savi, they are incorrect. The path loss equation (Savi Equation 2) should only be added to the EIRP of the signal source, not the received signal level (RSL) at some intermediate point.

V. CORRECT RESULTS OBTAINED BY APPROPRIATE USE OF THE EIRP OF THE SIGNAL SOURCE SUMMED WITH SAVI EQUATION 2 FOR PATH LOSS (WAIWW METHOD)

As stated above, Savi apparently used the -28.17 dBm (-58.17 dBW) received signal level (RSL) which it calculated at the 3 meter reference point instead of the EIRP of the signal source. To appropriately use Savi Equation 2, it should be summed with the EIRP of the signal source (the Savi interrogator).

To calculate the correct value for use in the equations, one first needs to take Savi's quoted EIRP for the interrogator (3.63 mW) and convert it to dBm or dBW:

P = 10 log (P1/P2)
P(dBm) = 10 log (3.63 mW/1 mW)
P(dBm) = 10 log (3.63)
P(dBm) = +5.599

or

P = 10 log (P1/P2)
P(dBW) = 10 log (.00363 W/1 W)
P(dBW) = 10 log (.00363)
P(dBW) = -24.401

Once the figure for EIRP of the signal source is obtained, it can properly be added to the results from Savi Equation 2 (the path loss equation).

By appropriately summing the EIRP of the signal source with the path loss from Savi Equation 2, the following (correct) results are obtained:

1 kilometer

RSL(dBm) = P(dBm) + L(dB)
RSL(dBm) = (+5.599)+ (-85.30)
RSL(dBm) = -79.60 dBm

or

RSL(dBW) = P(dBW) + L(dB)
RSL(dBW) = (-24.401) + (-85.30)
RSL(dBW) = -109.60 dBW

These results are reasonably close to those reported by the ARRL for 1 kilometer (-79.38 dBm or -109.38 dBW)

0.1 kilometer

RSL(dBm) = P(dBm) + L(dB)
RSL(dBm) = (+5.599) + (-65.30)
RSL(dBm) = -59.60 dBm

or

RSL(dBW) = P(dBW) + L(dB)
RSL(dBW) = (-24.401) + (-65.30)
RSL(dBW) = -89.60 dBW

These results are reasonably close to those reported by the ARRL for 0.1 kilometer (-59.38 dBm or -89.38 dBW)

VI. DIMENSIONAL ANALYSIS

Dimensional analysis is a tool used by engineers as a “sanity check” on calculations. This method is used to make sure that no terms have been incorrectly included or excluded, and to assure that all necessary conversion factors have been employed. For example, if one wanted to use equations for velocity which are based on “feet per second”, a conversion factor would be necessary if the velocity was specified in “furlongs per fortnight”.

The use of dimensional analysis might have prevented the failure of one of the recent NASA Mars missions. If some one had had access to all of the relevant data, a check of dimensions and units would have found a discrepancy. As it turned out, NASA was working with thrust (force) in terms of “Newtons” (a metric unit), while one of the NASA contractors was working with thrust (force) in terms of pounds (a British unit). This resulted in the computation of an incorrect “burn duration” which caused the spacecraft not to achieve the proper orbit around the planet Mars.

Dimensional analysis is a useful tool, but it is not foolproof. Although an equation (or set of equations) with dimensional inconsistencies would obviously be incorrect, equations which are dimensionally consistent may or may not be correct.

VII. SAVI METHOD OF SUMMING SAVI EQUATION 1 (RLS AT 3 METER REFERENCE POINT) AND SAVI EQUATION 2 (PATH LOSS) FAILS DIMENSIONAL ANALYSIS

One may perform a dimensional analysis consistency check on the procedure of summing Savi Equation 1 and Savi Equation 2. For the purpose of this example, the signal source is assumed to be the Savi interrogator (110,000 uV/m @ 3 meters), and the distance is assumed to be 1 kilometer. The procedure appears below:

1. Rewrite Savi Equation 1 and Savi Equation 2 in a matrix.
2. Place like terms in each column
3. Since Savi Equation 2 is for path loss, the values in this row are being signed as negative numbers
4. Total the terms in each column
5. Add terms in bottom row horizontally across to obtain result

Values

	Power Levels	Constant Terms	20 log (E) Terms	20 log (D) Terms	20 log (F) terms	
Savi Equation 1 (RSL at 3 meter reference point)	Power in dBm =	-77	+100.82	(none)	-52.85	
Savi Equation 2 (path loss)	Path Loss in dB =	-32.45	(none)	-0	-52.85	
	RSL(dBm) =	-109.45	+100.82	-0	-105.70	-114.33 dBm

D = Distance in kilometers (1 kilometer)
E = Field strength at 3 meter reference point (110,000 microvolts/meter)
F = Frequency (433.92 MHz)

The result is reasonably close to the -112.57 dBm (-142.57 dBW) figure which was reported by Savi for 1 kilometer.

However, if the values are substituted with the formula terms, the dimensional inconsistency becomes apparent:

Formulas

	Power Levels	Constant Terms	20 log (E) Terms	20 log (D) Terms	20 log (F) Terms	
Savi Equation 1 (RSL at 3 meter reference point)	Power in dBm =	Constant Term 1	+20 log (E)	(none)	-20 log (F)	
Savi Equation 2 (path loss)	Path Loss in dB =	Constant Term 2	(none)	-20 log (D)	-20 log (F)	
	RSL(dBm) =	Constant Term 3	+20 log (E)	-20 log (D)	-40 log (F)	Power (dBm)

D = Distance in kilometers
E = Field strength at 3 meter reference point in microvolts/meter
F = Frequency in MHz

Reading horizontally across the bottom row of the matrix incorrectly suggests that the received signal level (RSL) in dBm at 1 kilometer may be obtained by summing a constant term, a field strength term (+20 log (E)), a distance term (-20 log (D)), and a frequency term (-40 log (F)). However, since the -20 log (F) term is being added twice (once from each equation), the frequency term is dimensionally inappropriate:

The +20 log (E) term indicates that the RSL is proportional to the square of the field strength at the reference point

The -20 log (D) term indicates that the RSL is proportional to the inverse square of the distance from the source

The -40 log (F) term indicates that the RSL is proportional to the inverse 4^{th} power of the frequency

The claim of an inverse 4^{th} power relationship for the frequency is physically and mathematically absurd. Therefore, this method fails dimensional analysis.

VIII. ARRL METHOD OF ADJUSTING SAVI EQUATION 1 (RSL AT 3 METER REFERENCE POINT) WITH A DISTANCE TERM PASSES DIMENSIONAL ANALYSIS

ARRL has proposed that the RSL at any point of interest may be obtained by using a -20 log (D) term for distance correction. One may perform a dimensional analysis consistency check on the procedure of summing Savi Equation 1 and the ARRL distance correction term. For the purpose of this example, the signal source is assumed to be the Savi interrogator (110,000 uV/m @ 3 meters), and the distance is assumed to be 1 kilometer. The procedure appears below:

1. Rewrite Savi Equation 1 and the ARRL distance correction term in a matrix.
2. Place like terms in each column
3. Total the terms in each column
4. Add terms in bottom row horizontally across to obtain result

Values

	Power Levels	Constant Terms	20 log (E) Terms	20 log (D) Terms	20 log (F) Terms	
Savi Equation 1 (RSL at 3 meter reference point)	Power in dBm =	-77	+100.82	(none)	-52.85	
ARRL Distance Correction Term	Loss proportional to distance ratio (distance normalized to 3 meter reference distance)	(none)	(none)	-50.46	(none)	
	RSL(dBm) =	-77	+100.82	-50.46	-52.85	-79.49 dBm

D = Distance ratio (1000 meters/3 meters)
E = Field strength at 3 meter reference point (110,000 microvolts/meter)
F = Frequency (433.92 MHz)

The result is reasonably close to the -79.38 dBm (-109.38 dBW) figure which was reported by ARRL for 1 kilometer.

As a further check, the values may be substituted with the formula terms to assure that the result is dimensionally consistent:

Formulas

	Power Levels	Constant Terms	20 log (E) Terms	20 log (D) Terms	20 log (F) Terms	
Savi Equation 1 (RSL at 3 meter reference point)	Power in dBm =	Constant Term 1	+20 log (E)	(none)	-20 log (F)	
ARRL Distance Correction Term	Loss proportional to distance ratio (distance normalized to 3 meter reference distance	(none)	(none)	-20 log (D1/D2)	(none)	
	RSL(dBm) =	Constant Term 1	+20 log (E)	-20 log (D1/D2)	-20 log (F)	= Power in dBm

D1 = Distance in meters to point of interest (1000 meters)
D2 = Reference distance (3 meters)
E = Field strength at 3 meter reference point in microvolts/meter
F = Frequency in MHz

Reading horizontally across the bottom row of the matrix shows that the received signal level (RSL) in dBm may be obtained by summing a constant term, a field strength term (+20 log (E)), a distance term (-20 log (D)), and a frequency term (-20 log (F)).

The +20 log (E) term indicates that the RSL is proportional to the square of the field strength at the reference point

The -20 log (D) term indicates that the RSL is proportional to the inverse square of the distance ratio (distance of interest over 3-meter reference distance).

The -20 log (F) term indicates that the RSL is proportional to the inverse square of the frequency

All of the terms are dimensionally consistent. Therefore, this method passes dimensional analysis.

IX. WA2IWW METHOD OF SUMMING EIRP OF SIGNAL SOURCE WITH SAVI EQUATION 2 (PATH LOSS) PASSES DIMENSIONAL ANALYSIS

WA2IWW has proposed that the RSL at any point may be obtained by summing the EIRP of the signal source with Savi Equation 2. For the purpose of this example, the signal source is assumed to be the Savi interrogator (110,000 uV/m @ 3 meters), and the distance is assumed to be 1 kilometer. The procedure to perform a dimensional analysis consistency check appears below:

1. Rewrite the EIRP of the source and Savi Equation 2 in a matrix.
2. Place like terms in each column
3. Since Savi Equation 2 is for path loss, the values in this row are being signed as negative numbers
4. Total the terms in each column
5. Add terms in bottom row horizontally across to obtain result

Values

	Power Levels	EIRP at Source (dBm)	Constant Terms	20 log (D) Terms	20 log (F) Terms	
EIRP of Source (dBm)	Power in dBm =	+5.599	(none)	(none)	(none)	
Savi Equation 2 (path loss)	Loss Related To Distance From Signal Source	(none)	-32.45	-0	-52.85	
	RSL(dBm) =	+5.599	-32.45	-0	-52.85	-79.70 dBm

P = Power level at source (+5.56 dBm)
D = Distance in kilometers (1 kilometer)
F = Frequency (433.92 MHz)

The result is reasonably close to the -79.59 dBm (-109.59 dBW) figure which is computed by WA2IWW's Excel Spreadsheet (Appendix 1) for 1 kilometer.

As a further check, the values may be substituted with the formula terms to assure that the result is dimensionally consistent:

Formulas

	Power Levels	EIRP at Source (dBm)	Constant Terms	20 log (D) Terms	20 log (F) Terms	
EIRP of Source (dBm)	Power in dBm =	+10 log (P)	(none)	(none)	(none)	
Savi Equation 2 (path loss)	Loss Related To Distance From Signal Source	(none)	Constant Term 1	-20 log (D)	-20 log (F)	
	RSL(dBm) =	+10 log (P)	Constant Term 1	-20 log (D)	-20 log (F)	= Power in dBm

P = Power level at source (dBm)
D = Distance in kilometers
F = Frequency in MHz

Reading horizontally across the bottom row of the matrix shows that the received signal level (RSL) in dBm may be obtained by summing a constant term, a power term (+10 log (P)), a distance term (-20 log (D)), and a frequency term (-20 log (F)).

The +10 log (P) term indicates that the RSL is proportional to the EIRP of the signal source

The -20 log (D) term indicates that the RSL is proportional to the inverse square of the distance from the signal source

The -20 log (F) term indicates that the RSL is proportional to the inverse square of the frequency

All of the terms are dimensionally consistent. Therefore, this method passes dimensional analysis.

X. CONCLUSION

Savi's formulas are used incorrectly in their presentations. Savi has made serious errors in several scientific disciplines, and has not detected or corrected them. These errors may be verified by experts in the various fields.

Engineering - Engineers would realize the validity and importance of performing dimensional analysis on equations.

Mathematics – A mathematician (or math text book) would verify the definition of the following terms:

> 10 log (x) – is proportional to x (x)
> 20 log (x) – is proportional to the square of x (x^2)
> 40 log (x) – is proportional to the 4th power of x (x^4)
>
> -10 log (x) – is inversely proportional to x (1/x)
> -20 log (x) – is inversely proportional to the square of x ($1/x^2$)
> -40 log (x) – is inversely proportional to the 4th power of x ($1/x^4$)

Physics – A physicist (or physics text book) would verify that:

> Electric fields, magnetic fields, and received signal levels (RSLs) follow an inverse squared relationship with distance:
>
> (-20 log (D), or $1/D^2$)

Telecommunications Engineering – A telecommunications engineer should realize that the claim that received signal level (RSL) is proportional to the inverse 4th power of the frequency (implied by summing Sav1 Equation 1 with Savi Equation 2) is physically and mathematically absurd. In addition, a telecommunications engineer should also be familiar with the physics principles noted above (inverse square relationship with distance for electric fields, magnetic fields, and received signal levels (RSLs).

These errors invalidate large sections of the mathematics contained in at least four (4) of Savi's written presentations in this proceeding:

March 16, 2001	- Reply Comments of Savi Technology, Inc.
February 7, 2001	- Notice of *Ex Parte* Presentation in ET Docket No. 01-278
February 12, 2002	- Comments of Savi Technology, Inc.
March 12, 2002	- Reply Comments of Savi Technology, Inc.

In summary, much of Savi's engineering data is seriously flawed. The calculated levels of the Savi Interrogators and Tags are at least +33 dB higher than the figures submitted by Savi. Other Savi figures based on this error are also incorrect.

Savi's introduction of erroneous engineering data to the Commission's rulemaking process (along with Savi's subsequent failure to identify or correct the errors) calls the entire Savi petition and analysis into question.

Given all of Savi's errors which arise directly and indirectly from the inappropriate use of formulas, Savi has not made its case that the proposed new Savi system (and associated proposed rule changes) will not cause harmful interference to primary and secondary licensed users of the band.

For these reasons, and other reasons which were presented during the Comment and Reply Comment periods, the Commission should determine that the Savi petition is not in the public interest, convenience, or necessity, and should be denied.

Respectfully submitted,

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